SAMPLE COURSE SYLLABUS
Year 1

DOE Reference: Solar Energy Technology, CIP Code: 47.0703

Course Description: "Bright Solar Futures" is an active demonstration, hands-on training program Pennsylvania Career & Technical Education (CTE) for high school students to gain a working understanding of solar installation, energy conservation, work-site safety, construction basics, and solar and weatherization industry career pathways/ job readiness. The program encompasses solar installation application, design, installation, and maintenance of photovoltaic (PV) systems. This program includes lab-based training and field trips to multiple solar and weatherization sites as available. This three-year program has an emphasis on industry certification including an opportunity to sit for the NABCEP (North American Board of Certified Energy Practitioners) Associate Installer credential.

Year One Course Objectives

Upon completion of Year 1, students will:

Solar Technology

- Describe construction and solar safety components and tools
- Establish a safety plan that is practiced and used in all work
- Understand effective assembly of PV system components, sizing, design and the installation process by practice installing on a flat and mock roof
- Describe elements of solar interconnection
- Describe and demonstrate knowledge of electricity basics
- Describe racking systems, energy storage, sun science and sizing
- Explore solar industry roles
- Discuss PV system quality assurance, performance analysis and maintenance

Weatherization/Energy Efficiency

While a solar system in a home provides resource saving technology, the building condition and energy practices of the people that live there are critical in optimizing this savings. Weatherization Installation is an established industry and is a companion part of the work of a Solar Technician. This part of the curriculum is meant to provide skills as a Retrofit Install Technician as an important part of the overall Solar Curriculum.

Upon completion of Year 1, students will:

- Describe the interconnection of systems using the "House As a System" framework
- Describe the weatherization process, including the "building science" behind air leakage, use of insulation and air-sealing materials
- Perform energy audit procedures including set up and use of a blower door
- Explore baseload and seasonal load
- Describe common moisture problems in homes and their prevention and remediation
- Practice basic air-sealing and insulation tasks
- Identify tools appropriate to a variety of applications, describe their maintenance and appropriate use

Student Support: Life Skills and Professional Skills

An important part of the Solar Energy Technology CTE Program success includes attention to teaching life skills and supporting personal and professional skills. This must be included for this program to be successful. The life skills training protocol used in this program is included in Toolkit. Time is built into the schedule for this component and is shown in the yearly time allotment at the end of this document.

For the Philadelphia Energy Authority and the School District of Philadelphia demonstration, Tina Pelzer and the Faces And Voices Of Reason (FAVOR) team provide curriculum and teaching to develop these skills. FAVOR assists and supports trainees (personally and professionally) with tools to promote engagement, self-efficacy, focus and communication skills, and help navigate challenges that may arise throughout the course. FAVOR coordinates with the classroom teacher, students and student's families using a case management approach to assist with ongoing support and strategies for trainees to be successful. Highlights of this support aids student development in the:

- Use of a variety of professional and personal skills including professional etiquette, time management, emotional intelligence, and stress management.
- Development of personal and professional skills including confidence building strategies, trauma informed practices, goal setting, problem solving strategies, effective communication, and team building.
- Ability to describe the top ten skills employers want, job application skills, resume and cover letter preparation, and effective job interview skills.
- Planning career path goals and strategies

Week 1 - Intro & Solar Safety

- Course Introduction (Introductory Lesson) (Y1 Wk 1 Lesson 1)
  - Introduction to solar gear (solar panels, MLPEs, rails, flashing, inverters, etc.) (Introductory Lesson)
  - Introduce teacher devised checklists/rubrics/quizzes as assessment tools for the program
- Solar Personal Protective Equipment (PPE) (Y1 Wk 1 Lesson 2)
  - Introduction to Personal Fall Arrest Systems (PFAS)
  - Introduction to mock roof
  - Introduction of rules for mock roof
- Ladder safety & carrying (Y1 Wk 1 Lesson 3)
  - Proper Harness and Lifeline Use

Week 2 - Safety and Hands-on Solar Components and Tools

- Emergency Safety plans (Y1 Wk2 Lesson 1)
  - Designate “safety students” and create a rotation for the class
  - Students develop an Emergency Action Plan
  - First aid review
- Intro to tool safety, care and maintenance (Y1 Wk2 Lesson 2)
- Hands on with solar equipment: demonstrate how to properly carry a solar panel, racking equipment, inverters and balance of systems (BOS) components.
- Introduction to Installation (Y1 Wk2 Lesson 3)
  - Measuring and marking roof for solar
  - Demonstrate flashing installation
  - Overview of flat roof design systems for solar installation

Week 3 - Practice Installing on Mock Roof (Y1 Wk2 Lesson 3 continued)

- Mock roof

Week 4 - Practice Installing on Flat Roof (Y1 Wk2 Lesson 3 continued)

- Installing on a flat roof with ballast weight
- Racking specifications

Week 5 - Introduction to PV Systems Design & Solar Interconnection

- Introduction to basic PV Systems Design considerations (Y1 Wk5 Lesson 1)
- Manufacturers’ Specifications - SolarEdge inverter (Y1 Wk 5 Lesson 2)
- Discuss, demonstrate and perform solar interconnection (line side tap and backfeed breaker) (Y1 Wk5 Lesson 3)
- Solar labeling (Y1 Wk5 Lesson 4)

Week 6 - Electricity Basics, Safety and Intro to NEC

- Introduction to Electricity Basics and Terminology (Y1 Wk6 Lesson 1)
  - Voltage & Current
  - Alternating Current (AC) vs Direct Current (DC)
  - Power vs Energy
  - Ohm's Law - Resistance & Continuity
- Introduction to the National Electric Code (NEC) (Y1 Wk6 Lesson 2)
  - NEC Responsibilities
  - NEC 690 Solar Definitions
- Electrical Safety (Y1 Wk6 Lesson 3)

Week 7 - Solar Racking Systems

- Mounting and Structural Considerations (Y1 Wk7 Lesson 1)
- Primary Components vs Balance of System (BOS) Components (Y1 Wk2 Lesson 3 continued)
- Mechanical Installation Process (Y1 Wk2 Lesson 3 continued)
  - Introduction: Steps in the Mechanical Installation Process for Flush Roof Mount Systems
  - Introduction: Steps in the Mechanical Installation Process for Ballasted Systems
  - Introduction: Steps in the Mechanical Installation Process for Ground & Pole Mount Systems

Week 8 - Solar Industry Roles (Y1 Wk8 Lesson 1)

- Solar Installation Company Roles
- What Role Could Be a Good Fit for You? Career Choices.
- Insight Into the Solar Industry Business Model
- The Steps in the Overall Solar Energy System Installation Process
- Sales to Permission to Operate (PTO)
- Insight into the Installer Role
- Insight into the Solar Sales Role
- Insight into the Field Service Technician Role
- Introduction to Solar Economics - Costs vs Benefits

Week 9 - Solar Energy Basics & OSHA

- Principles and Physics of Energy (Y1 Wk9 Lesson 1)
- Why Solar? (Y1 Wk9 Lesson 2)
  - The Role Energy Plays In Everyday Life
  - Our Personal Connection to Energy
  - How and Where Energy Is Produced
  - How The Electrical Grid Operates
  - Centralized vs Distributed Generation
  - The Difference Between Photovoltaics (PV) & Solar Thermal
  - Measuring Power - How to Know When Power Is Present
  - Understanding Loads
  - Introduction to Meters / Testing Equipment
  - Energy Saving measures
- Impact of Energy Systems: Social, Economic, Health and Environment (Y1 Wk9 Lesson 3)
- Safety (Y1 Wk6 Lesson 3 continued)
  - Introduction to Occupational Safety and Health Administration (OSHA)
  - Review OSHA Responsibilities
  - Emergency management

Week 10 - Electrical Basics (continued)

- Electrical Basics continued (Y1 Wk6 Lesson 1 continued)
  - Ohm's Law Calculations - The Ohm's Law Formula
  - Measuring Voltage & Current With a Multimeter
  - The Metric System in Solar
  - Power Calculations - The Power Formula
  - nergy Calculations - The Energy Formula
- Measuring Resistance & Continuity with a Multimeter (Y1 Wk10 Lesson 1)
- Grounding (Y1 Wk10 Lesson 2)

Week 11 - Types of Solar Systems

- Solar PV Markets and Applications (Y1 Wk5 Lesson 1 continued)
- Different System Types (grid-direct, stand alone/off-grid, hybrid) (Y1 Wk11 Lesson 1)
  - 3 Primary Types - Grid Tied, Off Grid & Grid Tied with Battery Back-UpAdvantages and Challenges of Solar
- What is Building Integrated Photovoltaics (BIPV)? (i.e solar shingles)

Week 12 - Electrical Basics Continued

- Home Wiring (Y1 Wk12 Lesson 1)
  - Types of Direct Current Wiring Connections
  - Series vs. Parallel Connections
- Electrical Safety (Y1 Wk6 Lesson 3 continued)
  - De-Energizing a Solar Energy System - Disconnects
  - Introduction to Over Current Protection Devices (OCPD)
  - Lock-Out-Tag-Out (LOTO) Systems

Week 13 - Energy Storage (continued) (Y1 Wk13 Lesson 1)

- Energy Storage Introduction
  - Why Do We Need Energy Storage?
  - Battery Technologies & Terminology
  - Energy Storage System Components
- Function of a Charge ControllerEnergy Storage System Types
- Energy Storage System Maintenance
- The Future of Energy Storage

Week 14 - Energy Storage (continued)

- Energy storage hands-on activities (Y1 Wk13 Lesson 1 continued)
  - Battery safety
  - DC coupling vs. AC coupling storage
  - How to crimp ring connectors for battery cables
  - BMS: Battery Management Systems
  - DC appliances
  - Design for off grid homes

Week 15 - Solar Fundamentals

- Solar Energy Fundamentals (Y1 Wk15 Lesson 1)
- Solar PV System Sizing (Y1 Wk15 Lesson)
- How Solar Modules Are Tested, Priced and Sold - Module Labels / Performance Data
- Hands on: use a multimeter, light meter, and pyrometer to measure the output of a solar panel (Y1 Wk10 Lesson 1 continued)
- Principles of Energy: Measurement, Thermodynamics, Forms (Y1 Wk9 Lesson 1 continued)

Week 16 - Earth Science Basics (Y1 Wk16 Lesson 1)

- Impact of the Seasons on Solar Energy System Performance
- Sun Path - Earth's Rotation & Revolution
- Sun Path - Winter & Summer Solstice / Equinox
- How to Interpret Sun Path Charts
- Discussion of how a solar path finder works
- Peak Sun Hours

Week 17 - Solar Fundamentals (continued)

- Standard Test Conditions (Y2 Wk 16 Lesson 1)
  - How STC Impacts Module's Voltage & Current Specifications p44
  - Connecting STC to Electricity Basics - Voltage & Current (Y1 Wk10 Lesson 1 continued)
  - Introduction to Solar Time
  - How to Measure The Amount of Sun - Irradiance / Insolation
- Measuring Irradiance - Utilizing an Irradiance Meter (Y1 Wk10 Lesson 1 continued)

Week 18 -Solar Fundamentals: Solar Site Analysis (continued)

- Solar Site Analysis (Y1 Wk Lesson 18)
  - Solar Orientation
  - Tilt and Azimuth / Solar Angles
  - Understanding Latitude vs Longitude
- Measuring Tilt & Azimuth - Utilizing an Inclinometer & Compass

Week 19 - Interconnection Types

- Interconnections and Commissioning (Y1 Wk19 Lesson 1)
  - Safety issues
  - Supply/line side connection benefits and drawbacks
  - Load side connection: backfeed breaker. Review backfeed breaker sizing rule (120% rule)
  - Discussion of how busbars work in terms of voltage (120v per line) and two pole breakers
  - Demonstrate how to create more room in a breaker panel using tandem breakers

Week 20 - Mid-Term Practice & Assessments

Lab practicals in which students demonstrate knowledge and skills to-date with:

- Field made connector test
- Flashing test
- Wire termination test
- Proper carrying of solar panel
- Proper ladder setup
- Proper use of harness, lifeline, and roof anchor

WEATHERIZATION UNIT BEGINS

Week 21 - Energy Conservation and Introduction to Weatherization (3 days)

- Energy Efficiency
- PPE Introduction for Energy Conservation Work
- Full PPE LAB for Energy Conservation Introduction to Energy Conservation
- Overview and Introduction to the Energy Conservation Handbook
- Weatherization Process
- Roles and Duties of Weatherization Technician
- Weatherization and the Weatherization Assistance Program
- Cost-Effective Requirements; Savings to Investment Ratio

Week 22 - Building Science: House as a System (1 day, 3 ½ days = 2.5 days)

- Hand and Power Tools Used for Weatherization: Use and Safety
- House as a System Components
- Building Science
- Health and Safety in the Home
- Problems: Moisture, Mold Mildew and Health

Week 23 - Building Science: House as a System (continued) (5 days)

- Baseload/Seasonal Load
- Introduction to Energy Conservation Materials and Measurement
- Blower Door Lecture (Lesson 16)
- Blower Door Lab (Lesson 17)
- Health and Safety in the Home - Indoor Air Quality (Lesson 18)

Week 24 - Air Movement (5 days)

- Principles of Energy: Measurement, Thermodynamics, Forms (Lesson 19)
- Air Movement: Driving Forces of Air Movement (Lesson 20)
- Leakage and Replacement (Lesson 21)
- Safety: Power Tools and Hand Tools (Lesson 22)

Week 25 Air Sealing (4 days)

- Air Sealing Methods: Insulation Introduction (Lesson 23)
    - Older Insulation Materials
    - Facings and Barriers
- Thermal Boundary: Insulation: How It Works, Types* (Lesson 24) (*two 90-min periods needed)
- LAB: Practice Air Sealing Holes, Cracks, and Large Openings (Lesson 25)

Week 26 - Insulation (5 days)

- LAB: Sealing the Rim or Band Joist (Lesson 26)
- LAB: Dense Pack Insulation Lab (Lesson 27)

Week 27 - Auditing & Applying Auditing Information (5 days)

- Energy Auditor Work Scope (Work Order) (Lesson 28)
- Auditing: Basics of Combustion Analysis (Lesson 29)
- Energy Efficient Appliances (Lesson 30)
- Lighting Efficiency (Lesson 31)

Week 28 - Related Construction and Plumbing (5 days)

- Plumbing Applications (Lesson 32)
- Domestic Hot Water (Lesson 33)
- Building Codes: National, State, Local (Lesson 34)
- Framing: Balloon and Platform Framing (Lesson 35)

SOLAR UNIT RESUMES

Week 29 - Fourth Quarter Solar Basics Review

- Look at previous assessments and determine areas most important to review.
- Review/revisit previous lessons as needed
- Get students back into thinking about solar

Week 30 - Shading (3.5 days) (Y1 Wk30 Lesson 1)

- Shading - Solar's Toughest Opponent
- Inter-Row Shading
- Impacts of Shading on Solar Energy System Production
- Measuring Shadings Impact - Utilizing Shading Analysis Tools
- Intro to Conducting a Solar Site Survey
- Using a Solmetric Suneye for Seasonal Shading Analysis
- Creating and Interpreting Shading Reports

Week 31 - Introduction to Module Level Power Electronics (MLPE) (5 days)

(Y1 Wk2 Lesson 3 continued)

- Introduction to Module Level Power Electronics (MLPE)
- Benefits of MLPEs
- How MLPEs Help Prevent Negative Impacts of Shading
- Rapid Shutdown Requirements
- MLPE Specifics - MicroInverters and DC Optimizers
- Installing / Wiring MLPEs
- Baseload Review: Energy Analysis

Week 32 - Advanced Interconnections (5 days) (Y1 Wk2 Lesson 3 continued)

- OCPD's and Inverters
- Introduction to Inverter Continuous Output Current (COC)
- Introduction To Inverter Voltage Range / Maximum Input Voltage (MIV)
- Intro to Solar PV System Interconnection
- Point of Interconnection (POI)
- Main Service Panel (MSP) Fundamentals
- Supply Side vs Load Side Connections
- How a Supply Side Connection Is Made
- Insulation Piercing Connectors (IPC)
- How a Load Side Connection is Made
- Selecting a Solar Supply Breaker - 120% Rule / Calculation
- Matching a Solar Supply Breaker to an Inverter's Continuous Output Current - 125% safety Calculation

Week 33 - Review of Solar Components (3.5 days)

- Solar Components Definitions (Chap. 6 PV Basics Text)
- Off Grid Specific System Components Definitions (Chap. 6 PV Basics Text)

Week 34 - Review of Systems Types and Terms (4 days)

- Review: Grid Tied Solar Energy System Components
- Solar Circuits
- Circuit Conductors - PV Source / PV Output / Inverter Input / Inverter Output
- Installing a Typical Grid Tied Solar Energy System
- Flashing, Racking, Modules, Combiner / Junction Box, Inverter w/ DC Disconnect, AC Disconnect, POI

Week 35 - Wiring Review (5 days)

- Solar PV System Conductors
- Intro to Wire Sizing - American Wire Gauge (AWG)
- Understanding Ampacity and Wire Sizing
- Introduction to PV System Grounding
- Bonding .vs Grounding
- PV Wire Characteristics
- THHN/ THWN Characteristics
- Making Field Made Connectors
- Making PV Source Circuit Conductors - "Home Runs"

Week 36 - PV Design review (4 days)

- Intro to PV System Sizing Principles
- Factors That Determine System Sizing
- Grid Tied .vs Off Grid Sizing Factors
- How To Calculate System Losses / Derating

Week 37 - Electrical Review (5 days)

- PV System Electrical Design
- Electrical Diagrams - Single Line and 3 Line Diagrams
- OCPDs in Electrical Circuits
- Selecting Fuses and Circuit Breakers
- String Sizing
- How to do Voltage and Temperature Calculations

Week 38 - Final Hands-On Assessment (4 days)

- Have students lay out and install six solar panels and MLPE's on the mock roof.
- Assessment ends with wires properly terminated with junction box on the roof.
- OPTIONAL: Include interconnection if students have been excelling in installation and have strong understanding of interconnection.
- Check wire management, check MLPEs, check flashing, check bonding and grounding of rails and panels.

Week 39 - Organize and Clean Up (5 days)

(Last Week of School) Closing Activities/Awards/Celebrations

- Lab Clean Up
- Awards and Recognition
- Celebration

Week 40 (2 days)

SAMPLE COURSE SYLLABUS
Year 2

DOE Reference: Solar Energy Technology, CIP Code: 47.0703

Course Description: "Bright Solar Futures" Year 2 continues Pennsylvania Career & Technical Education (CTE) Solar Technician and Weatherization Technician training program for high school students to solidify their working understanding of solar installation, energy conservation, work-site safety, construction basics, and job readiness. Since new students are permitted to enroll in Year 2, the curriculum reviews all of Year 1 including safety, solar design, installation, and maintenance of photovoltaic (PV) systems. This program includes lab-based training and increases the use of field trips to observe installations and maintenance. In Year 1, the primary focus of Solar Installation provided the lens to view an introduction to all areas of Solar Technology. In Year 2, Installation remains an important focus as does Safety and Hazards; formal OSHA 10 training occurs in Year 2. Solar Project Management and Design as well as Solar Maintenance and Operations take on a larger part of the year.

Year Two Course Objectives

Upon completion of Year 2, students will:

Solar Technology

- Demonstrate use of Solar Technology and Weatherization safety equipment
- Successfully complete OSHA 10 training
- Identify and use tools appropriate to a variety of applications, describe their maintenance and appropriate use and storage
- List the main elements of Solar System Management: components, procurement, mounting systems, balance of system (BOS), material readiness, site assessment, and installation process
- Explain the variety of solar industry roles and examine related personal interests and goals
- Use solar design software for drawing PV installations
- Complete a PV system build with minimal teacher support, effective assembly of PV system components, sizing, design and the installation process
- Describe and plan the major elements of solar projects and design, including energy storage systems, interconnections, wiring, module-level power electronics (MLPE)
- Discuss PV system quality assurance, performance analysis, operations, and maintenance
- Review and demonstrate knowledge of solar and electricity fundamentals

Weatherization/Energy Efficiency

While a solar system in a home provides resource saving technology, the building condition and energy practices of the people that live there are critical in optimizing this savings. Weatherization Installation is an established industry and is a companion part of the work of a Solar Technician. This part of the curriculum is meant to provide skills as a Retrofit Install Technician as an important part of the overall Solar Curriculum.

Upon completion of Year 2, students will:

- Describe the interconnection of systems using the “House As a System”
- Describe building science framework and principles
- Describe the weatherization process, including the science behind air leakage, use of insulation and air-sealing materials
- Perform energy audit procedures including set up and use of a blower door to
- identify weatherization issues
- Prioritize remediation strategies for specific buildings and develop a work scope
- Describe common moisture problems in homes and their prevention and remediation
- Examine Solar Technology and Energy Efficiency career paths and develop a career portfolio
- Develop and demonstrate a variety of work related/life skills including preparation, time management, personal and professional problem solving strategies, team building, effective communication, and effective interviewing skills
- Examine internship opportunities and interview for summer work placements

Student Support: Life Skills and Professional Skills

An important part of the Solar Energy Technology CTE Program success includes attention to teaching life skills and supporting personal and professional skills. This must be included for this program to be successful. The life skills training protocol used in this program is included in Toolkit. Time is built into the schedule for this component and is shown in the yearly time allotment at the end of this document.

For the Philadelphia Energy Authority and the School District of Philadelphia demonstration, Tina Pelzer and the Faces And Voices Of Reason (FAVOR) team provide curriculum and teaching to develop these skills. FAVOR assists and supports trainees (personally and professionally) with tools to promote engagement, self-efficacy, focus and communication skills, and help navigate challenges that may arise throughout the course. FAVOR coordinates with the classroom teacher, students and student’s families using a case management approach to assist with ongoing support and strategies for trainees to be successful. Highlights of this support aids student development in the:

- Use of a variety of professional and personal skills including professional etiquette, time management, emotional intelligence, and stress management.
- Development of personal and professional skills including confidence building strategies, trauma informed practices, goal setting, problem solving strategies, effective communication, and team building.
- Ability to describe the top ten skills employers want, job application skills, resume and cover letter preparation, and effective job interview skills.
- Planning career path goals and strategies

***OSHA 10 Training** - It is recommended that any school sponsoring this program includes a formal OSHA10 training component that leads to a nationally recognized credential in addition to the safety lessons already included in the curriculum. This training is appropriate at the beginning of the Year 2 during the first quarter. During our pilot phase of the project the School District of Philadelphia selected an OSHA10 General Industry - Manufacturing online training program offered by https://www.careersafeonline.com/.

Week 1 - Intro & Solar Safety Review

- Course Introduction (Y2 Wk1 Lesson 1)
  - Introduction/review of solar gear (solar panels, MLPEs, rails, flashing, inverters, etc.)
  - Review how to be hands-on with solar equipment: demonstrate how to properly carry solar panels, racking equipment, inverters and balance of system (BOS) components.
- Solar Personal Protective Equipment (PPE) (Y2 Wk 1 Lesson 2)
  - Personal Fall Arrest Systems (PFAS)
  - Review of mock roof - rules and safety
- Ladder safety & carrying (Y2 Wk1 Lesson 3)
  - Proper harness and lifeline use
- Lock-Out-Tag-Out (LOTO) Systems
- De-Energizing a Solar Energy System - Disconnects

Week 2 - Safety and Hands-on Solar Components and Tools Review

- Emergency Preparedness (Y2 Wk2 Lesson 1)
  - Designate safety students and what the rotation will be
  - Develop EAPs
  - First aid
- Hand & power tools - safety, care and maintenance (Y2 Wk2 Lesson 2)
- Introduction/Review of Installation (Y2 Wk2 Lesson 3)
  - Start measuring roof for solar and marking roof; if possible demonstrate flashing installation
  - Provide an overview and detailed description of flat roof design systems for solar installation

Week 3 - Review of Installing on Mock and Flat Roof

- Intro to installation continued (Y2 Wk2 Lesson 3 continued)
  - Review installation procedures as needed including:
    - How an inverter works; how to wire an inverter
    - Racking, wiring, field made connectors, etc.
  - Installing solar on mock roof
  - Installing solar on flat roof using ballast weight
- Installing Flashings - roof waterproofing (Y2 Wk3 Lesson 1)

Week 4 - Introduction to Solar Project Management

- Identify and explain all Solar System Components (Y2 Wk4 Lesson 1)
  - What is solar BOS and what components are part of BOS?
  - Describe the function of various pieces of equipment
  - Discussion of commercial solar panels vs. residential (60 cell vs. 72 cell)
  - What are bifacial panels? What are half cell panels?
- In depth discussion of different mounting systems: Flush mount, pergola, ballast weight, standing seam, etc. (Y2 Wk4 Lesson 2)

Week 5 - Site Assessment (Y2 Wk5 Lesson 1)

- Discover peak sun hours
- Shading studies
- Magnetic declamation
- Ground mount vs. roof mount
- Railless, flush mount racking
- Single vs dual axis tracker
- System sizing (Review of Y1 Wk15 Lesson 2)
- Inter row shading calculations
- Demonstrate knowledge of mfg specs
- Mock site visit activity (Y2 Wk5 Lesson 2)

Week 6 - Solar Racking Systems & Installation

- Identifying Solar Installation Components (Y2 Wk2 Lesson 3 continued)
  - Describe primary components vs BOS components
  - Practice installation and interconnections
  - Perform partial installations as needed
- Mounting and Structural Considerations (Y2 Wk4 Lesson 2 continued)
  - Grounding (clamps bond frame to rails)
- Connections (Y2 Wk6 Lesson 3)

Week 7 - Solar Project Management (continued)

- Creating a bill of materials (BOM)
- Installation Practice continued (Y2 Wk2 Lesson 3 continued)
  - Mechanical Installation Process for Flush Roof Mount Systems
  - Mechanical Installation Process for Ballasted Systems
  - Mechanical Installation Process for Ground & Pole Mount Systems

Week 8 - Solar Sales

- Intro to Solar Sales (Y2 Wk8 Lesson 1)
  - Insight Into the Solar Industry Business Model
  - The Steps in the overall solar energy system installation process
  - Sales to permission-to-operate (PTO)
  - Insight into the Solar Sales role
  - Communicating the PV system (Y2 WK 8 Lesson 2)

Week 9 - Data Acquisition Systems for Solar (DAS)

- Solar Monitoring (Y2 Wk9 Lesson 1)
  - Residential vs commercial - DAS
  - Current transformer and potential transformer; proper installation
  - Other Services
    - Home consumption monitoring
    - Inverter-based EV charging
    - Transfer switches
    - Critical load center
    - Dry contactors and load management

Week 10 - Solar Energy Basics (Y2 Wk10 Lesson 1)

- Why Solar? The Role Energy Plays In Everyday Life: Our Personal Connection to Energy
- Introduction to solar economics - costs vs benefits
- How and where energy Is produced
- How The electrical grid operates: Four Steps in the Utility Grid Process
  - Generation / Transmission / Distribution / Consumption
- Centralized vs Distributed Generation
- Electrical transmission and distribution systems
- How PECO works
  - Reading an Electrical Bill
- The difference between PV & solar thermal
- Measuring Power: How to know when power Is present
- Understanding loads
- Introduction to meters and testing equipment (Y2 Wk10 Lesson 2)
  - Measuring voltage & current with a multimeter
  - Power calculations - the power formula
  - Energy calculations - the energy formula
  - Measuring resistance & continuity with a multimeter

Week 11 - Types of Solar Systems

- Solar PV markets and applications
- Different system types (Y2 Wk11 Lesson 1)
  - Grid tied
  - Off grid
  - Grid tied with battery back-up
- Advantages and challenges of solar
- What is building integrated photovoltaics (BIPV)?

Week 12 - Energy Storage (Y2 Wk12 Lesson 1)

- Energy storage Introduction
- Why do we need energy storage?
- Energy storage system types
- Energy storage system maintenance
- Battery technologies & terminology
- Energy storage system components
- Function of a charge controller
- The future of energy storage
- Energy storage hands-on activities
    - Battery safety
    - DC coupling vs. AC coupling storage
    - How to crimp ring connectors for battery cables
    - Battery management systems (BMS)
    - DC appliances
    - Design for off grid homes

Week 13 - Solar Design

- Elements of a Plan Set (Y2 Wk13 Lesson 1)
    - Understanding solar panel specifications and data sheets
- Solar Design (Y2 Wk13 Lesson 2)
    - Designing for proper voltage in series circuits
    - Calculating and using temperature coefficient (and effect on stringing)
    - Parallel wiring (AC and DC)
    - Understanding MLPE and how they affect design
    - Rapid shutdown: design and function

Week 14 - Solar Maintenance and Operations

- Introduction to M & O (Y2 Wk14 Lesson 5)
- Troubleshooting (Y2 Wk14 Lesson 1)
    - Phone screening
    - Frequent trouble points - junction boxes, field made connectors, MLPE failure, inverter failure
    - Coordination of warranty repairs and regular service checks
- On-site inspection of solar array (Y2 Wk14 Lesson 2)
- Reading and troubleshooting online monitoring (Y2 Wk14 Lesson 3)
    - Monitoring software
- Battery settings and solar interactions
- Cleaning, repair of squirrel damage, installation ol squirrel guards
- Testing for electrical issues - ground fault, underproduction, nuisance tripping of over-current protection, etc. (Y2 Wk14 Lesson 4)
- Solar inverter preventative maintenance
- Audit energy production

Week 15 - Solar Fundamentals

- Solar Site Analysis (Y2 Week 15 Lesson 1)
  - Solar orientation
  - Tilt and azimuth - solar angles
    - Utilizing an inclinometer & compass
  - Understanding latitude and longitude
  - Impact of the seasons on solar energy system performance
- Sun Path (Y2 Wk15 Lesson 2)
  - Earth's rotation & revolution
  - Winter & summer solstice and equinox
  - How to Interpret sun path charts
  - Discussion and demonstration of how a solar path finder works
  - Peak sun hours
  - Introduction to solar time

Week 16 - Solar Fundamentals (continued)

- Standard Test Conditions (Y2 Wk16 Lesson 1)
  - How STC Impacts Module's Voltage & Current Specifications p44
  - Connecting STC to Electricity Basics - Voltage & Current
  - How solar modules are tested, priced and sold - module labels performance data
  - Monthly Assessment
- Tools of the Trade (Y2 Wk16 Lesson 2)
- Hands on: use a multimeter, light meter, and pyrometer to measure the output of a solar panel, measuring irradiance - utilizing an irradiance meter, how to measure the amount of sun - irradiance / insolation

Week 17 - Solar Design (continued)

- Construct a solar management plan for the system (Y2 Wk17 Lesson 1)
  - Research and practice - applying for permits
  - Research and practice - applying for interconnection
- Activity - Design a system for a specific house and location that will use affordable solar panels
  - Create BOM and doc set (for permitting and interconnection)

Week 18 - Solar Design Software (Y2 Wk18 Lesson 1)

- Perform a solar design using one of the following platforms
  - Google Sketch-Up (free)
  - CAD system for drawing solar
  - Alternative paid software, if available
    - Helioscope/Aurora
    - Solargraf
- Use of Drones

Week 19 - Inspecting Interconnection Types - Hands-on Work

- Safety issues (Y2 Wk19 Lesson 1)
- Supply/line side connection benefits and drawbacks
- Load side connection: backfeed breaker
  - Review backfeed breaker sizing rule (120% rule)
- How busbars work in terms of voltage (120v per line) and two pole breakers
- Demonstrate how to create more room in a breaker panel using tandem breakers

Week 20 - Practice Assessments

- Lab practicals in which students demonstrate knowledge and skills to-date

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WEATHERIZATION UNIT BEGINS

Week 21 - Energy Conservation and Introduction to Weatherization (3 days)

- Introduction to energy conservation and energy efficiency
- PPE introduction for energy conservation work
- Full PPE lab for energy conservation
- Overview and Introduction to the Energy Conservation Handbook
- Introduction to the weatherization process
- Roles and duties of weatherization technician
- Weatherization and the Weatherization Assistance Program
- Cost-Effective requirements and savings to investment ratio

Week 22 - Building Science: House as a System (1 day, 3 ½ days = 2.5 days)

- Hand and power tools used for weatherization - use and safety
- House as a system - components of building science
- Health and safety - moisture, evaporation, condensation,
- Problems - moisture, mold, mildew and health

Week 23 - Building Science: House as a System (continued) (5 days)

- Baseload/Seasonal Load
- Introduction to energy conservation materials and measurement
- Blower door lecture
- Blower door lab
- Health and safety in the home - indoor air quality

Week 24 - Air Movement (5 days)

- Principles of energy - measurement, thermodynamics, forms
- Air movement
- Driving forces of air movement
- Air leakage and replacement
- Common conditions: wind, stack and mechanical effects

Week 25 - Air Sealing (4 days)

- Air sealing methods
- Insulation introduction
- Thermal boundaries
- Tools, consumables, safety equipment
- LAB: Practice air sealing holes, cracks and large openings
- LAB: Sealing the rim or band joist

Week 26 - Insulation (5 days)

- Insulation: How it works and types
- Older insulation materials
- LAB: Dense pack insulation
- Facings and barriers

Week 27 - Auditing and Applying Auditing Information (5 days)

- Energy auditor work scope/work orders
- Auditing: Basics of combustion analysis
- Changing energy use behaviors
- Energy efficient appliances

Week 28 - Related Construction and Plumbing (5 days)

- Plumbing applications
- Domestic hot water
- Building codes: national, state, local
- Framing: Balloon and platform framing

SOLAR UNIT RESUMES

Week 29 - Solar Review

- Look at previous assessments and determine areas most important to review.
- Review electricity basics for understanding and practical use with topics as needed:
  - Electricity Basics and Terminology
  - National Electric Code (NEC); NEC 690 Solar Definitions; NEC Responsibilities
  - Over-Current Protection Devices (OCPD)
  - Lock-Out-Tag-Out (LOTO) systems
  - Alternating Current (AC) vs Direct Current (DC); DC to AC conversion
  - Types of direct current wiring connections
  - Power vs energy
  - Voltage & current
  - Ohm's Law - resistance & continuity
  - Series vs. parallel connections
  - The proportional relationship between voltage & current
  - Introduction to IV curves
  - Factors That impact a solar energy system's performance
    - Environmental conditions
    - Temperature's effect on voltage
    - The effect of irradiance on current
    - Different ways of testing PV
  - Maximum Power Point Tracking (MPPT)

Week 30 - Review of Shading (3.5 days)

- Shading - solar's toughest opponent
- Inter-row shading
- Impacts of shading on solar energy system production
- Measuring shadings impact - utilizing shading analysis tools
- Intro to conducting a solar site survey
- Using a solmetric suneye for seasonal shading analysis
- Creating and interpreting shading reports

Week 31 - Introduction to Module Level Power Electronics (MLPE) (5 days)

- Introduction to module level power electronics (MLPE) (Y2 Wk2 Lesson 3 continued)
  - Benefits of MLPEs
  - How MLPEs help prevent negative impacts of shading
  - Rapid shutdown requirements
  - MLPE specifics - microInverters and DC optimizers
  - Installing - wiring MLPEs
  - Baseload review - energy analysis

Week 32 - Advanced Interconnections (5 days)

- Advanced Interconnections (Y2 Wk32 Lesson 1)
  - OCPD's and inverters
  - Introduction to inverter continuous output current (COC)
  - Introduction To inverter voltage range - maximum input voltage (MIV)
  - Intro to solar PV system interconnection
  - Point of interconnection (POI)
  - Main service panel (MSP) fundamentals
  - Supply side vs load side connections
  - How a supply side connection is made
  - Insulation piercing connectors (IPC)
  - How a load side connection is made
  - Selecting a solar supply breaker - 120% rule and calculation
  - Matching a solar supply breaker to an inverter's COC - 125% calculation
- Solar labeling (Y2 Wk32 Lesson 2)

Week 33 - Solar PV Systems Review (3.5 days)

- How solar PV works
- Solar PV system mechanical design
- Mechanical drawings - Using CAD and other design tools
- Reading a solar plan set
- Intro to the 5 primary mechanical PV systems
- Flush roof mount, ballasted, ground mount, pole mount and BIPV
- Tracking systems - dual and single axis
- Choosing racking and other system construction components
- Monthly assessment
- Introduction to solar PV System commissioning and performance testing
- Introduction to solar PV system monitoring
- Introduction to solar energy system troubleshooting and operations & maintenance (O&M)solar
- Introduction to solar PV system quality assurance

Week 34 - Review & Design and Build a PV and Storage System for an Off-grid House (4 days)

- Review: Grid tied solar energy system components
- Solar circuits
- Circuit conductors - PV source, PV output, inverter Input, inverter output
- Installing a typical grid tied solar energy system
- Flashing, racking, modules, combiner, junction box, inverter w/ DC disconnect, AC disconnect, POI
- Conducting a post installation quality assurance inspection

Week 35 - Wiring Review (5 days)

- Solar PV system conductors
- Intro to wire sizing - american wire gauge (AWG)
- Understanding ampacity and wire sizing
- Introduction to PV system grounding
- Bonding vs grounding
- PV wire characteristics
- THHN/THWN characteristics
- Making field made connectors
- Making PV source circuit conductors - “Home Runs”

Week 36 - Electrical & PV Design review (4 days)

- Intro to PV system sizing principles
- Factors that determine system sizing
- Grid tied vs Off grid sizing factors
- How To calculate system losses - derating
- PV system electrical design
- Electrical diagrams - single line and 3 line diagrams
- OCPDs in Electrical Circuits
- Selecting fuses and circuit breakers
- String sizing
- How to do voltage and temperature calculations

Week 37 - Final Hands-On Assessment (5 days)

- Have students lay out and install six solar panels and MLPE’s on the mock roof
- Assessment ends with wires properly terminated with junction box on the roof

Week 38 - Summer Internship Preparation (4 days)

- Review professional skills and workplace etiquette
- Confirm work site information with students
- Provide work expectation orientation and interviews with internship sponsors where possible

Week 39 - Organize and Clean Up (5 days)

(Last Week of School) Closing Activities

- Plans for internships/summer work
- Lab clean up
- Awards and recognition
- Celebration

Week 40 (2 days)

DOE Reference: Solar Energy Technology, CIP Code: 47.0703

SAMPLE COURSE SYLLABUS
Year 3

DOE Reference: Solar Energy Technology, CIP Code: 47.0703

Course Description: "Bright Solar Futures" Year 3 completes the Pennsylvania Career & Technical Education (CTE) Solar Technician and Weatherization Technician training program for high school students. This represents a demonstration year where students show their knowledge and skills pertaining to solar installation, energy conservation, work-site safety, construction basics, and job readiness. While some of the year includes lab-based training, field trips, guest speakers and on-site installation work will be provided weekly. Ability to observe and participate in active work sites undergoing solar installation, energy auditing and/or remediation are the ideal way to apply what was learned in the first two years. In Year 3 students complete a Team Capstone Project in the lab as a major portion of their grade. The program's emphasis on industry certification includes an opportunity to sit for the NABCEP Photovoltaic Associate credential at the end of the third year.

Year Three Course Objectives

Upon completion of Year 3, students will:

Solar Technology

- Complete a Capstone Team Project over the course of the year that includes forming a solar technology company; within a given budget demonstrate the solar value proposition, develop a solar proposal and marketing plan; complete a design, operation, and install plan with the assistance of industry professionals and field trips. All weekly activities should be geared toward the completion of the capstone.
- Engage in solar management planning and solar design in order to develop the capstone project
- Complete solar site assessments for real properties through both in-class case studies and field trips to actual sites.
- Demonstrate the correct use and installation of all solar gear including the effective assembly of PV system components, sizing, design and the installation process for a complete system on both flat and mock roofs
- Author a plan for solar sales for the Capstone Project; roleplay solar sales activities; plan for customer acquisition
- Design a house solar system
- Plan and design off-grid and hybrid Solar Systems
- Perform PV system quality assurance, performance analysis and maintenance tasks
- Present Capstone Team Projects to outside industry experts
- Prepare for and take the NABCEP Associate Examination

Weatherization

- Students are divided into Retrofit Teams for this Year 3 final project. As teams, they will develop a menu of weatherization professional skills and energy efficiency client education plans that they will present as their final project.
- In teams, evaluate and perform weatherization measures for buildings in the lab and in the field.
- Demonstrate knowledge of building science and house as a system through team projects that require energy efficiency auditing and weatherization installation tasks.
- Perform energy audit procedures including set up and use of a blower door to develop a whole house weatherization plan
- Demonstrate use the appropriate of insulation and air-sealing methods and materials
- Provide a plan for house efficiency and weatherization including common moisture problems, their prevention and remediation that demonstrates understanding of building science and “house as a system” principles
- Develop a client education plan for changing behavior related to energy efficiency
- Given a specific house audit, role play with a client options for remediation, financial help, and setting priorities
- Students demonstrate use, care, stocking for work, and transportation of a wide variety of materials and tools needed for both solar and energy efficiency work.

Student Support: Life Skills and Professional Skills

An important part of the Pennsylvania Career & Technical Education (CTE) Solar Technician and Weatherization Technician training program success includes attention to teaching life skills and supporting personal and professional skills. This must be included for this program to be successful. The life skills training protocol used in this program is included in Toolkit Outline. Time is built into the schedule for this component and is shown in the yearly time allotment at the end of this document.

For the Philadelphia Energy Authority and the School District of Philadelphia demonstration, Tina Pelzer and the Faces And Voices Of Reason (FAVOR) team provide curriculum and teaching to develop these skills. FAVOR assists and supports trainees (personally and professionally) with tools to promote engagement, self-efficacy, focus and communication skills, and help navigate challenges that may arise throughout the course. FAVOR coordinates with the classroom teacher, students and students’ families using a case management approach to assist with ongoing support and strategies for trainees to be successful. Highlights of this support develops:

- Use of a variety of professional and personal skills including professional etiquette, time management, emotional intelligence, and stress management.
- Development of personal and professional skills including confidence building strategies, trauma informed practices, goal setting, problem solving strategies, effective communication, and team building.
- Ability to describe the top ten skills employers want, job application skill, resume and cover letter preparation, and effective job interview skills.
- Planning career path goals and strategies

Week 1 & 2 - Introduction to SENIOR CAPSTONE PROJECT & Review of Solar Project Management

- Course Overview:
  - Year 3 including live installations, field trips to live installs, full systems installs in the lab, NABCEP, Career Pathways
  - Life Skills Program; on-going individual counseling and support; professional skills
- Introduction to Senior Capstone Team Group Projects (Y3 ALL WEEKS Lesson 1)
  - Student teams develop a proposal for a solar company and presentation of a solar project to a potential client
  - Break into teams and form solar companies
  - Proposals must include:
    - Design for solar proposal and marketing plan that demonstrates the value proposition that they want to focus on (i.e. environ, econ or community) and how will they reach people (ads, etc)
    - A budget (i.e. for marketing) or make up their own guerilla marketing plan
    - Detailed sales approach
    - Work plan that includes technical specifications and costs (including savings)
  - Work proceeds on a weekly basis over three school quarters
  - Sales people and designers come into the class on the regular basis

Review of Solar Project Management and Design (Please refer to Years 1 & 2 for review materials)

- Students provide their explanations/teacher reviews as needed:
  - Identify and explain all Solar System Components
  - Explain procurement issues and their remedies should you not be able to get a specific part
  - In depth discussion of different mounting systems: Flush mount, pergola, ballast weight, standing seam, etc.
  - What is solar BOS and what parts are components of BOS?
  - Ensure the truck has all of the needed components and tools.
  - Describe the function of various pieces of equipment
  - Discussion of commercial solar panels vs. residential (60 cell vs. 72 cell)
  - What are bifacial panels? What are half cell panels?
- Site Assessment Review
  - Discover peak sun hours
  - Shading studies
  - Magnetic declamation
  - Ground mount vs. roof mount
  - Railless, flush mount racking
  - Single vs. dual axis tracker
  - System sizing
  - Inter Row shading calculations
  - Demonstrate knowledge of mfg. specs

- Solar Racking Systems/Installation (Please refer to Years 1 & 2 for review materials)
  - Identifying solar installation components
  - Describe primary components vs. balance of system (BOS) components and practice installation and

interconnections
    - Perform partial installations as needed
    - Solar labeling

- Solar Project Management Continued (Please refer to Years 1 & 2 for review materials)
    - Creating a bill of materials (BOM)
    - Mechanical installation process for flush roof mount systems and ballasted systems
    - Introduction: Steps in the mechanical installation process for ground & pole mount systems

- Solar Design (Please refer to Years 1 & 2 for review materials)
    - Designing for proper voltage in series circuits
    - Calculating and using temperature coefficient (and effect on stringing)
    - Parallel wiring (AC and DC)
    - Understanding solar panel specifications and data sheets
    - Understanding MLPE and how they affect design
    - Rapid shutdown: design and functionRe
    - Create BOM and Doc Set (for permitting and interconnection)
    - Construct a Solar Management plan for the system
    - For this specific jurisdiction, research and practice: Applying for Permits
    - For this specific jurisdiction, research and practice: Applying for Interconnection

Week 3 - Review of Safety Basics & Tool Use and Maintenance (Please refer to Years 1 & 2 for review materials)

- Review and Assessment of skills: teacher assesses student knowledge and ability to demonstrate use of the following:
    - Purpose and use of solar gear (solar panels, MLPEs, rails, flashing, inverters, etc.)
    - Solar Personal Protective Equipment (PPE)
    - Use of safety rules and conduct for work on the mock roof
    - Review of Ladder safety & carrying
    - Personal Fall Arrest Systems (PFAS)
    - Review of Harness and Lifeline Use
    - Review all OSHA topics
    - Determine further instruction on topics after review and student demo
- Safety Knowledge and Demonstration of Hands-on Solar Components and Tools
    - Show team leadership in designating “safety students” and developing a team rotation
    - Develop a plan for a solar installation and implement the components
        - Measurement and marking of roof for solar, layout flashing installation, roof water-proofing, etc.
        - Repeat for flat roof systems for solar
    - Students demonstrate how to properly carry a solar panel, racking, inverters and balance of systems (teacher devised checklists/rubrics should be used for assessment during the process)
    - Design their own checklists for the solar installations; review lists with student
    - Demonstrate correct use and maintenance of power tools for solar during installation
    - From student performance, determine the need for tutorials during the process or after completion.

Week 4 - Transition to Solar Sales

- Review the solar value proposition (Y3 Wk4 Lesson 1)
  - Value proposition to the customer
    - Economic (bring in PECO bills, calc per kilowatt cost, how does net metering work)
    - Environmental - current energy production issues, why and solar solves these issues
    - Local jobs & community - current energy production happens far from local communities (in rural areas) thus jobs are not local; solar creates local generation and jobs
  - Discuss Solar Renewable Energy Certificates (SREC) or Alternative Energy Credits (AEC); (0.5% solar by 2021 in PA - generation rights) https://www.srectrade.com
  - Analysis of components (i.e roof, electrical bills,...)
  - State Renewable Portfolio Standards (RPS) and federal
    - PA - Alternative Energy Portfolio Standard (AEPS)

Week 5 - Career Pathways in Solar Sales (Y3 Wk5 Lesson Resources)

(Teacher and School Counselor should collaborate to arrange for guest speakers and career workshops throughout this week)

- Guest employers sessions
  - Inside Sales:
    - Initial customer conversations/creating an interest
    - Eliminating customers who are not serious
    - Assigning customers to the right salesperson
    - Battery specialists
    - Commercial specialists
  - Outside Sales
    - How to begin conversations with a new customer
    - Building trust
    - Scripted vs non-scripted conversation
    - ZOOM vs In-person
- Post-Secondary next steps - NABCEP sales credential
- Professional communication
- Workplace contributions/presentations
- Job search workshop
- Resume writing workshop

Week 6 - Financing Models for Solar

- Policy and Financing (Y3 Wk6 Lesson 1)
- Cash purchase
- Loan Options
  - Secured vs. unsecured loans
  - Closing costs vs. dealer fees
  - CPACE: Commercial Property Assessed Clean Energy lending
  - Discuss repayment of tax credit to lower loan principle
- Lease options
  - Who owns the SRECs?
  - Who takes the tax credit?
- PPA (Power Purchase Agreement)
  - Prepaid PPA for nonprofits
  - Negotiable PPA terms

Week 7 - Customer Acquisition (Please refer to Years 1 & 2 for review materials)

(Y3 Wk7 Lesson Resources)

- How to attract clients and whose job is it?
  - Referrals from previous clients (check-ins with client)
  - Buying leads from web sites
  - Google AdWords
  - Social media
  - Email campaigns
  - Tabling
  - Event sponsorship
  - Information sessions/speaking engagements
  - Solarize campaign
- Client selection - are all clients right for you?
- Students select 2-3 of the above and write acquisition plan for Capstone.

Week 8 - Design and Build your own Solar Proposal for Customer (Y3 Wk8 Lesson Resources)

- Review Sample Competing Proposals
  - What should appear on cover sheet
  - How do you display savings to client (Day 1 vs 30-Year Savings)
  - How to develop branding
  - How to present the value proposition
  - Proposal styles and their impact: long and detailed, short and concise, choice of language
  - Offer an Operations and Maintenance guide
- Student Teams create a detailed outline for what should appear in their proposals

Week 9 - Design a Home Solar System (for a specific house and location that will use affordable solar panels) (Y3 Wk9 Lesson Resources)

- Affordable vs. premium panels, when to use; choice when space is at a premium
- Use Google Sketch-Up (free) or Helioscope/Aurora to design the system (CAD system for drawing solar)
- Model the solar design energy production using PV Watt
- Model the payback using the PV Watt and PECO energy bill rates
- Understand the impact the Investment Tax Credit and accelerated depreciation (commercial projects)

Week 10 - Solar Sales - Role Playing

- Practice for Capstone
  - Develop Team (Company Identity): names, logo, mission statement, business plan, etc.
  - Create a pitch that is able to answer customer questions:
    - Consideration of different housing stocks in the sales pitch
    - Shading analysis
    - Roofing analysis, conditions of the roof, construction requirements before solar
    - Conduit runs and disconnect
    - Discuss the value proposition (warranties, costs, SREC's, etc)
  - "Knock on door" - role playing with 3 types of clients (amenable, neutral, difficult); how do you pitch to each type
  - How do you build trust when cold knocking (finding common ground)
- Lessons learned and improvements
- Include 1-2 guest speakers or field trip sessions where students see sales pitches in action from industry professionals

Week 11 - Review Installing on Mock and Flat Roof (Please refer to Years 1 & 2 for review materials)

- Complete plans for a solar installation on the mock roof
- Provide group and individual feedback for installation teams
- Plan installing solar on flat roof using ballast weight
- How to work around roof obstructions & the concept of keystone panels

Week 12 - Review of Off-Grid and Hybrid Solar Systems: Comparison of On and Off Grid/ Hybrid Systems (Compare how off grid systems relate to the off grid/hybrid systems) (Please refer to Years 1 & 2 for review materials)

- Battery sizing calculation
  - Power vs. energy sizing
  - Analysis of house loads
  - Days of autonomy
- AC/DC battery coupling
- Different battery chemistries
  - Valve regulated flooded lead acid (VRFLA)
  - Lead acid batteries
  - Lithium Ion
    - Lithium cobalt
    - Lithium iron phosphate
  - Future storage technology
- Battery safety
- Housing design - using as little energy as possible, Earth-D
- EarthShip designs
  - Engage students in an existing contest/design challenge for an off-grid house such as: (https://tinyhousetalk.com/2020-off-grid-houses-on-the-move-tiny-house-design-contest/)

Week 13 - Off-Grid and Hybrid Solar Systems (continued) (Please refer to Years 1 & 2 for review materials)

- Housing design - using as little energy as possible, Earth-Ship designs
- Electrical design of off-grid and hybrid houses
- Create an electrical design document to complete the electrical hookup of batteries and panel

Week 14 - Off Grid and Hybrid Solar Systems - Solar Interconnection (Please refer to Years 1 & 2 for review materials)

- Review and Assessment of skills: review of traditional interconnection and how it relates to off-grid/ hybrid systems; teacher assesses student knowledge and ability to use the following through appropriate activities:
  - Point of interconnection (POI)
  - Main service panel (MSP) fundamentals
  - Supply side .vs load side connections
  - How a supply side connection is made
  - Insulation piercing connectors (IPC)
  - How a load side connection is made
  - Selecting a solar supply breaker - 120% rule / calculation
  - Matching a solar supply breaker to an inverter's COC - 125% calculation
- Compare and contrast tradition with off-grid/hybrid
  - Transfer switches
  - Lack of interconnection with a grid
  - Hybrid - backup system; full home? critical load?
  - Days of autonomy - back-up plans (i.e. generators)

Week 15 - Wires, Connectors, Grounding Demonstrations (Please refer to Years 1 & 2 for review materials)

Students provide hands-on demonstrations of the following:

- Solar PV system conductors
- Wire sizing - American wire gauge (AWG)
- Understanding ampacity and wire sizing
- PV system grounding; bonding vs grounding
- PV wire characteristics
- THHN/ THWN characteristics
- Make field made connectors
- Make PV source circuit conductors - “home runs”

Week 16 - Advanced Solar Project Management (Please refer to Years 1 & 2 for review materials)

- Identify and explain all solar system components
- Explain procurement issues and their remedy. What do you do if you cannot get a certain part?
- In depth discussion of different mounting systems: flush mount, pergola, ballast weight, standing seam, etc.
- What is solar BOS and what parts are part of BOS?
- Ensure the truck has all of the needed components and tools.
- Describe the function of various pieces of equipment
- Discussion of commercial solar panels vs. residential (60 cell vs. 72 cell)
- What are bifacial panels? What are half cell panels?

Week 17 - Site Assessment (Please refer to Years 1 & 2 for review materials)

- Discover peak sun hours
- Shading studies
- Magnetic declamation
- Ground mount vs roof mount;
- Railless, flush mount racking
- Single vs dual axis tracker
- System sizing
- Inter Row shading calculations
- Demonstrate knowledge of mfg. specs

Week 18 - Solar Project Management (continued) (Please refer to Years 1 & 2 for review materials)

- Creating a bill of materials (BOM)
- Mechanical installation process for:
    - Flush roof mount systems
    - Ballasted systems
    - Ground & pole mount systems

Week 19 - Data Acquisition Systems for Solar (DAS) (Please refer to Years 1 & 2 for review materials)

- Residential vs. commercial - DAS
- Current transformer and potential transformer; proper installation
- Other services
  - Home consumption monitoring
  - Inverter-based EV charging
  - Transfer switches
  - Critical load center
  - Dry contactors and load management

Week 20 - Solar Maintenance and Operations/Capstone Project Updating (End of quarter)

- Administration of O&M (Y3 Wk20 Lesson 1)
  - Phone screening
  - Reading and troubleshooting online monitoring
  - Frequent trouble points (junction boxes, field made connectors, MLPE failure, inverter failure)
  - Battery settings and solar interactions; on-site inspection of solar array
  - Cleaning; repair of squirrel damage; installation of squirrel guards
  - Testing for electrical issues (ground fault, underproduction, nuisance tripping of over-current protection, etc.)
  - Solar inverter preventative maintenance
  - Audit energy production
  - Coordination of warranty repairs and regular service checks
  - Monitoring software
  - Customer Education Guide
  - Measuring System Performance

WEATHERIZATION UNIT BEGINS

Week 21 - Energy Efficiency and Weatherization

Weekly Quizzes and Hands-On Assessments are to be scheduled by the teacher.

- Overview and assessment of knowledge of:
  - House as a System/Building Science
  - Blower door/Air Leakage/Sealing
  - Combustion analysis
  - Comprehensive house inspection and audit
  - National and local building codes (presented within related topics)
  - Advanced energy conservation materials, measurement, and management
- Form Retrofit Teams for Completing 3rd Year hands on projects and demonstrations (see checklist in Y3 Lesson 29).
- Review Safety as it relates to processes used in weatherization; Assess student skills; remediate/review as needed
  - Hand tools and power tools; consumables, safety equipment
  - Describe how students will be assessed in their ability to use auditing equipment, installation tools and materials
  - Ladder safety
  - Review knowledge of PPE, proper choice of PPE for specific work

Week 22 - Building Science/ House as a System and Principles of Energy

- Review and assess student knowledge of the fundamentals of weatherization process, most importantly:
  - House as a System
  - Building Science
    - Heat transfer
    - Driving forces of air movement; wind, stack, mechanical effect
  - Health and Safety:
    - Indoor Air Quality
    - Moisture, evaporation, condensation,
    - Inspection: structure damage, lead, asbestos, pest infestation (reasons for work deferral)
  - Baseload/seasonal load

Week 23 - Air Movement, Leakage and Sealing

- Advanced Air Leakage Diagnostics
  - Testing: Blower door, CO2, CO, zonal testing
- Advanced Air Sealing Methods
- Air Sealing Practice
  - Portable Spray Foam
  - Duct Sealing and Insulation
  - Air Sealing Lab: holes, cracks, and large openings
- Basics of Mechanical Ventilation Systems

Week 24 - Sealing and Insulation

- House Framing
- Thermal boundary: Facings and barriers
- R-Values and kinds of insulation
  - Insulation: how it works, types
  - Geographical R-values (determine what is needed in diff areas)
  - Type needed for jobs; calculate amount/thickness
  - National and local codes for sealing and insulation
- Student demonstration of insulationInsulation:
  - Loose fill
  - Open blow (specified amounts/jobs)
  - Dense pack, batt and dry crawl space
- Mock Up lab: high hats, ceiling, flue pipe with fire block

Week 25 - Energy Efficiency Strategies

- Energy efficient appliances and Energy use
  - Lighting, heating, electric appliances
- Client education:
  - Cost-effective requirements and Saving-to -Investment Ratio (SIR)
  - Client education topics and messaging
    - Behaviors for energy efficiency
    - User-friendly explanations for maintenance
  - Role play for changing human behavior

Week 26 - Construction Related Tasks for Weatherization

- Drywall installation
- Plumbing
- Doors and windows lab
- Lab roof repair: drainage plain, structure
  - Sloped: Shingles and replacement; nail problems
  - Low-sloped: minor cracks, blisters, flashings

Week 27 - Organizing for Work

- Organizing for Work
  - Work Scope and Implementation
  - Site plans/work orders, supplies and materials
  - Organization of tools and materials
  - Transportation of materials
  - Local codes for transport
- Teacher prepared final examination
- Completion of any Hands-On Demonstration by Team Members

Week 28 - Completion/Demonstration of Energy Efficiency/Final Exam

Most Hands-On Assessments have already been completed prior to this final week. Energy Efficiency Retrofit Teams are asked to demonstrate their skills and make final presentations. These presentations are determined by the teacher.

- Selected Hands-on Presentations: Teacher selects which teams will provide final demonstrations (See Energy Efficiency and Weatherization Retrofit Installer 3rd Year Project Checklist attached for suggested topics.
- Possible WHASI (Whole House Air Sealing and Insulation) testing (if included in the program)
- Last Day: Lab organization and clean-up

SOLAR UNIT RESUMES

Week 29 - Solar Sales (continued)

- Students continue to work on Team Capstone Projects
    - Proposals
    - Marketing plans
    - Sales approach
    - Zoom strategy
    - Closing scripts
    - Getting past customer objections via role play practice
    - Set customer expectations
    - Create and communicate timeline
    - Using knowledge gained through prior installations for future sales
    - Finalize budget plans

Week 30 - Year 3 Hands-On Solar Installation Demonstration (Please refer to Years 1 & 2 for review materials)

- Have students lay out and install six solar panels and MLPE's on the mock roof
- Assessment ends with wires properly terminated with junction box on the roof
- Assemble conduit, pull wire, and wire interconnections (line side and load side)

Week 31 - Career Planning (Request guidance counselor assist with this weeks activities)

- Guest employer presentations
- Build individualized career plans
  - Provide employer looking for a variety of jobs: sales, permitting, installation, project maintenance, operations and maintenance, procurement
- Post-Secondary education opportunities: community college, etc.
- Review of industry groups and professional resources
  - SEIA
  - SEPA
  - NABCEP
  - MSEIA
  - NREL
  - Vote Solar
- Job search workshop
- Resume writing workshop
- Mock interviews
- Create questions for professionals through understanding of solar industry roles
- Assemble an complete a career portfolio of chosen career path

Week 32 - Team Capstone Project Presentation Preparations

- Review of rubrics for final team preparations/project demonstrations
- Tutorials/make-up work time
- Incorporating feedback

Week 33 - Capstone Presentations (Juried by Industry Professionals)

- Teacher recruits industry professionals to serve as evaluators of Capstone presentation
- Industry Professionals provide verbal and written feedback to teams

Week 34 - NABCEP Review Week (1): PV Application

- Solar and Electrical Basics
  - National Electric Code (NEC)
  - NEC 690 solar definitions
  - Voltage & current
  - Ohm's Law / resistance & continuity
  - Power, energy and Ohm's Law calculations
  - Types of direct current (DC) wiring connections
  - Series vs. parallel connection
  - Alternating current (AC) .vs direct current (DC)

    - Electrical transmission and distribution systems
        - Steps in the utility grid process
            - Generation
            - Transmission
            - Distribution
            - Consumption
        - Centralized vs distributed generation
        - How PECO and energy companies work?
    - Use an electric bill for a customer to explain saving potential and costs over time
    - Difference between photovoltaics (PV) & solar thermal
    - Measuring power - how to know when power Is present
    - Understanding loads
    - Meters and testing equipment
        - Measuring Voltage, Current, Resistance & Continuity With a Multimeter
    - Occupational Safety and Health Administration (OSHA)
    - Types of direct current wiring connections
    - Energy storage - types, components, maintenance and future
        - Battery technologies & terminology
    - Function of a charge controller
    - De-Energizing a solar energy system - disconnects
    - Introduction to over current protection devices (OCPD)
    - Lock-Out-Tag-Out (LOTO) systems
- Solar Function and Inverter Wiring Demonstration
    - How solar PV works
    - How a solar inverter works
    - DC to AC conversion
    - Maximum Power Point Tracking (MPPT)
    - How to wire a solar inverter
- Earth and Sun Science
    - Impact of the seasons on solar energy system performance
    - Sun path - Earth's rotation & revolution
    - Sun path - winter & summer solstice / equinox
    - How to interpret sun path charts
    - Shading - Inter-Row shading
    - Impacts of shading on solar energy system production
    - Measuring shading's impact - utilizing shading analysis tools
    - Conducting a solar site survey
    - Using a solmetric suneye for seasonal shading analysis
    - Creating and interpreting shading reports

Week 35 - NABCEP Review (2): Sales & Economics

- Solar value proposition
    - Value proposition to the customer (economic, environmental, and local community)
    - Solar Renewable Energy Certificates (SREC) or Alternative Energy Credits (AEC); (0.5% solar by 2021 in PA - generation rights) - https://www.srectrade.com

    - Analysis of components (i.e roof, electrical bills,...)
    - State Renewable Portfolio Standards (RPS) and federal
        - PA - Alternative Energy Portfolio Standard (AEPS)
- Inside Sales:
    - Initial customer conversations/creating an interest
    - Eliminating customers who are not serious
    - Assigning customers to the right salesperson
    - Battery specialists
    - Commercial specialists
- Outside Sales
    - How to begin conversations with a new customer
    - Building trust
    - Scripted vs non-scripted conversation
    - Zoom vs in-person
- Financing Models for Solar
    - Cash purchase
    - Loan options
        - Secured vs. unsecured loans
        - Closing costs vs. dealer fees
        - CPACE: Commercial Property Assessed Clean Energy lending
        - Discuss repayment of tax credit to lower loan principle
    - Lease options
        - Who owns the SRECs?
        - Who takes the tax credit?
    - PPA (Power Purchase Agreement)
        - Prepaid PPA for nonprofits
        - Negotiable PPA terms
- Customer Acquisition
    - Attracting clients; roles for customer acquisition
        - Referrals from previous clients (check-ins with client)
        - Buying leads from web sites
        - Google AdWords
        - Social media
        - Email campaigns
        - Tabling
        - Event sponsorship
        - Information sessions/speaking engagements
        - Solarize campaigns
    - Client selection: Knowing if clients are right for your organization

Week 36 - Review/Prep Sessions for NABCEP Associates Exam (3): Design

- Solar Racking Systems
- Solar Design
  - System sizing principles; determining system sizing
  - Grid-tied vs off-grid sizing factors
  - How to calculate system losses / derating
  - Solar PV system mechanical design
  - Mechanical Drawings - CAD and Other Design Tools
  - Reading a solar plan set
  - Flush roof mount, ballasted, ground mount, pole mount and BIPV
  - Tracking systems - dual and single axis
  - Choosing racking and other system construction components
  - System commissioning and performance testing
  - Solar PV system monitoring and quality assurance
  - Intro to PV system electrical design
  - Electrical diagrams - single line and 3 line diagrams
  - OCPDs in electrical circuits
  - Selecting fuses and circuit breakers
  - String sizing
  - Voltage and temperature calculations
  - Grid-tied solar energy system components
  - Solar circuits
  - Circuit conductors - PV source / PV output / inverter input / inverter output
  - Installing a typical Grid-tied solar energy system
  - Flashing, racking, modules, combiner / junction box, inverter w/ DC disconnect, AC disconnect, POI
- Types of Solar Systems
  - Solar PV markets and applications
  - Advantages and challenges of solar
  - Building Integrated Photovoltaics (BIPV)
  - Energy saving measures
- Maximizing Solar Energy Capture
  - Solar energy fundamentals
  - Solar PV system sizing
  - Solar power vs solar energy
  - Peak sun hours
  - Standard test conditions
  - How solar modules are tested, priced and sold - module labels / performance data
  - Connecting STC to electricity basics - voltage & current
  - Principles of energy: measurement, thermodynamics, forms
  - Air movement
  - Solar time - solar orientation - tilt and azimuth / solar angles - utilizing an Inclinometer & compass
  - Understanding latitude vs longitude
  - How to measure the amount of sun - irradiance / insolation - utilizing an irradiance meter
  - Types of solar radiation

Week 37 - Review/Prep Sessions (4) for NABCEP Associates Exam: Installation

- Solar Racking Systems. Provide/identify/distinguish:
  - Demonstrated identification and function of all solar installation components
  - Primary components vs balance of system (BOS) components and their use
  - Mechanical installation process for flush roof mount systems, ballasted systems and ground & pole mount systems
- NABCEP: Associate Job Task Analysis (JTA) - Associate HANDBOOK
- Take practice NABCEP exam

Week 38 - Review/Prep Session (5) for NABCEP Operations and Maintenance & NABCEP Associates Scheduled Exam

- Operations & Maintenance
  - Factors that impact a solar energy system's performance
    - Environmental conditions
    - Temperature's effect on voltage
    - Effect of irradiance on current
  - Different ways of testing PV phone screening
  - Reading and troubleshooting online monitoring
  - Frequent trouble points (junction boxes, field made connectors, MLPE failure, inverter failure)
  - Battery settings and solar interactions; on-site inspection of solar array
  - Cleaning, repair of squirrel damage, installation of squirrel guards
  - Testing for electrical issues (ground fault, underproduction, nuisance tripping of over-current protection, etc.)
  - Solar inverter preventative maintenance
  - Auditing energy production
  - Coordination of warranty repairs and regular service checks
  - Solar PV system commissioning and performance testing
  - Solar PV system monitoring and monitoring software
  - Solar energy system troubleshooting and operations & maintenance (O&M)
  - Solar PV system quality assurance
- Scheduled NABCEP Associate Exam

Week 39 - Graduation Week

- Final employment preparation/troubleshooting
- Lab clean up
- Awards and recognition
- Celebration

Week 40 - Post Graduation Check-In